



HUNTER GEOPHYSICS

Specialists in unmarked grave detection and archaeological prospection

PO Box 1445, Central Park, Victoria 3145
Ph.: (03) 9913 2259 or Mob.: 0488 501 261

david.hunter@huntergeophysics.com
www.huntergeophysics.com

GEOPHYSICAL SURVEY REPORT

SITE NAME	[redacted] Cemetery
SITE CODE	2014/1
CLIENT	[redacted] Cemetery Trust
HERITAGE VICTORIA CODE	[redacted]
SURVEYORS	David Hunter, Shannon Hunter
SURVEY DATES	22-23 February, 1-2 and 15-16 March, 2014
REPORT SUBMISSION DATE	5th May 2014
REPORT AUTHOR	David Hunter



Copyright notice

Unless otherwise noted, all text, data and images shown herein are copyright Hunter Geophysics. This report may be distributed freely by the client on the provision that no changes are made to any part of the report, and that Hunter Geophysics are attributed authorship of the report. This notice does not override the copyright restrictions enforced by the State of Victoria for the distribution of its material which is contained in this document; any entity sharing this document should adhere to the State of Victoria's copyright restrictions.

Statement of indemnity

The results and interpretation of the geophysical surveys described herein should not be considered an absolute representation of the underlying soil or archaeological features, but instead as a hypothesis yet to be verified. Confirmation of geophysical interpretations is only possible through careful excavation.

While Hunter Geophysics aims to produce accurate interpretations of geophysical surveys, numerous unforeseeable issues may arise that may limit the accuracy of interpretations. These may include unforeseen soil or geological conditions, the presence of rabbit or other animal burrowing, the presence of tree/plant root systems, ploughing, site drainage and interference caused by variations in the Earth's magnetosphere and ionosphere, or interference caused by nearby radio transmitters.

Of particular importance is the similar appearance of boulders suspended in the soil profile (typical of granite bedrock as present at this site), tree roots and rabbit burrowing with unmarked graves. These factors are expected to have influenced the geophysical data described in this report; areas noted in the 'Results' section and associated figures as indicative of such features should be treated as if they were unmarked graves due to this uncertainty.

Stray radiowaves were detected by the ground-penetrating radar system during the execution of this geophysical survey, which is in breach of the conditions of the original contract. The interference caused by these signals - while limited - may have degraded the geophysical data. While Hunter Geophysics took reasonable steps to reduce this influence, it accepts no liability arising due to this interference.

Every effort is made to ensure that these risks are minimized, but Hunter Geophysics does not guarantee that the interpretations of geophysical data provided herein are accurate.

[redacted]

Executive summary

An intensive geophysical survey was undertaken by Hunter Geophysics at the [redacted] Cemetery for the purposes of locating unmarked graves. The geophysical investigation has not only determined the location of numerous unmarked graves, but has also detected the possible foundations of a gazebo.

Front cover image: view looking southeast from the northwestern end of the road running through the [redacted] Cemetery.

Table of contents

<u>Copyright notice</u>	2
<u>Statement of indemnity</u>	2
<u>Executive summary</u>	2
<u>Table of contents</u>	3
<u>Introduction</u>	4
Aims	4
Geography and topography	4
Site geology	5
Site weather conditions	7
Site history	8
<u>Methodology</u>	9
Data collection	9
Data processing	12
Reporting, mapping and archiving	16
<u>Results</u>	16
Ground-penetrating Radar survey	16
<u>Acknowledgments</u>	24
<u>Conclusion</u>	24
Satisfaction of objectives	24
Summary of results	24
Geophysical research value	24
Dissemination	25
Recommendations	25
What's on the USB	25
<u>References</u>	26

Introduction

Hunter Geophysics were commissioned by the [redacted] Cemetery Trust to undertake a geophysical survey of several areas within the [redacted] Cemetery, [redacted], Victoria. Heritage Victoria, a part of the Department of Planning and Community Development, was notified of the intention to perform the geophysical survey as per legislative requirements.

Aims

The geophysical survey was requested to determine the location of any unmarked graves within twelve areas at the [redacted] Cemetery. Local memory suggested that individuals may have been buried in the areas to be covered by the geophysical survey.

Geography and topography

The [redacted] Cemetery is located to the northeast of the township of [redacted], along the [redacted] Road. The southeastern entrance to the cemetery is located at Map Grid of Australia (MGA) coordinates [redacted].

**Image removed from
report to protect the
site's location.**

Figure 1: an overview map of the [redacted] area with the location of the cemetery shown (in red).

Base map data © State of Victoria, Department of Environment and Primary Industries 1997. Reproduced with permission.

The advice provided in this publication is intended as a source of information only. Always read the label before using any of the products mentioned. The State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

The cemetery is situated on a steep hillside (a 28-metre increase in elevation over the 200 metres from the entrance to the north-western fence) which was formed by the intrusion of an Upper Devonian granite and subsequent weathering of country rock (as per figure 4 on page 6), resulting in a colluvial gravel soil matrix.

Site geology

Please refer to the geological map on page 6. The [redacted] Cemetery is located on the interface between an Upper Devonian granite intrusion and the Pleistocene [redacted] Formation sands. The Ordovician [redacted] Sandstone is further northwest of the cemetery.

The [redacted] Sandstone was deposited 443-485 million years ago in a marine environment. The granite intruded the [redacted] Sandstone 358-382 million years ago and was overlain by the [redacted] Formation sands deposited over the last 2.5 million years. The local soil is a colluvial gravel deposit as noted earlier in this section.

**Image removed from
report to protect the
site's location.**

Figure 2: a detailed map of [redacted], with the cemetery shown (in red).

Base map data © State of Victoria, Department of Environment and Primary Industries 1997. Reproduced with permission.

The advice provided in this publication is intended as a source of information only. Always read the label before using any of the products mentioned. The State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

**Image removed from
report to protect the
site's location.**

Figure 3: an overview of the geological map of [redacted] and surrounds.

**Image removed from
report to protect the
site's location.**

Figure 4: local geological map in detail.

Geological map © State of Victoria, Department of Environment and Primary Industries 1997. Reproduced with permission.

The advice provided in this publication is intended as a source of information only. Always read the label before using any of the products mentioned. The State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Image removed from report to protect the site's location.

Figure 5: local geological map in detail. The [redacted] Cemetery is located on the interface between an Upper Devonian granite intrusion (shown in red) and the Pleistocene [redacted] Formation sands (shown in yellow). The Ordovician [redacted] Sandstone is further northwest of the cemetery (shown in blue). The boundary fence of the [redacted] Cemetery is shown in red towards the right side of the map.

Geological map © State of Victoria, Department of Environment and Primary Industries 1997. Reproduced with permission.

The advice provided in this publication is intended as a source of information only. Always read the label before using any of the products mentioned. The State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Site weather conditions

The geophysical survey was conducted across three field seasons: 22-23 February, 1-2 and 15-16 March, 2014. The Bureau of Meteorology records the following weather data for [redacted], a nearby town considered indicative of weather at the site:

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)
22nd February	12.5	28.7	0
23rd February	14.5	31.3	0
1st March	16.8	30.1	0
2nd March	14.3	30.3	2.4
15th March	13.9	30.4	0
16th March	11.9	19.0	15.6

All geophysical data were collected prior to the heavy rain on the 16th March. While no mosaic errors are expected to occur in geophysical data, survey areas were processed and interpreted individually rather than as a whole in order to prevent any degradation in data.

Site history

The history of the [redacted] Cemetery is poorly documented: the cemetery is not mentioned by any written records that may be found by following the steps in the ‘Background research’ section of Heritage Victoria’s ‘Guidelines for Conducting Historical Archaeological Surveys’. Therefore, members of the [redacted] Cemetery Trust were consulted regarding their memories of the cemetery.

Mr [redacted] advised that a gazebo once stood to the immediate southeast of the large tree in the middle of the cemetery (i.e. to the immediate southeast of the dry stone wall visible on the below map). The area indicated by Mr [redacted] showed patches of less-healthy grass, possibly indicative of buried foundations. This area was covered by the geophysical survey.

No other historical information regarding the site was ascertained.



Figure 6: [redacted] Cemetery site map.

Data collection

The client originally requested specific areas to be covered by the geophysical survey (as seen in figure 7 below); some areas were not surveyable due to surface obstacles. Figure 8 on page 10 shows the areas that were actually covered by the geophysical survey. Figure 9 shows the difference between the proposed survey areas and the actual survey areas (see page 11).

Ground-penetrating radar (GPR) data were collected by Hunter Geophysics in twelve survey areas using a Sensors and Software Noggin Utility SmartCart system and a Noggin antenna with a central transmitting frequency of 250MHz. Survey areas were staked out using a Topcon GR-3 RTK GNSS receiver; the RTK GNSS receiver was also used to collect geographic data pertaining to each ground-penetrating radar trace (i.e. latitude, longitude and elevation values were collected for each geophysical measurement) where sufficient satellite coverage was possible.



Figure 7: [redacted] Cemetery site map showing the originally-proposed survey areas (in blue).



Figure 8: [redacted] Cemetery site map showing the survey areas that were actually surveyed (in blue). The map also shows the name of each survey grid.

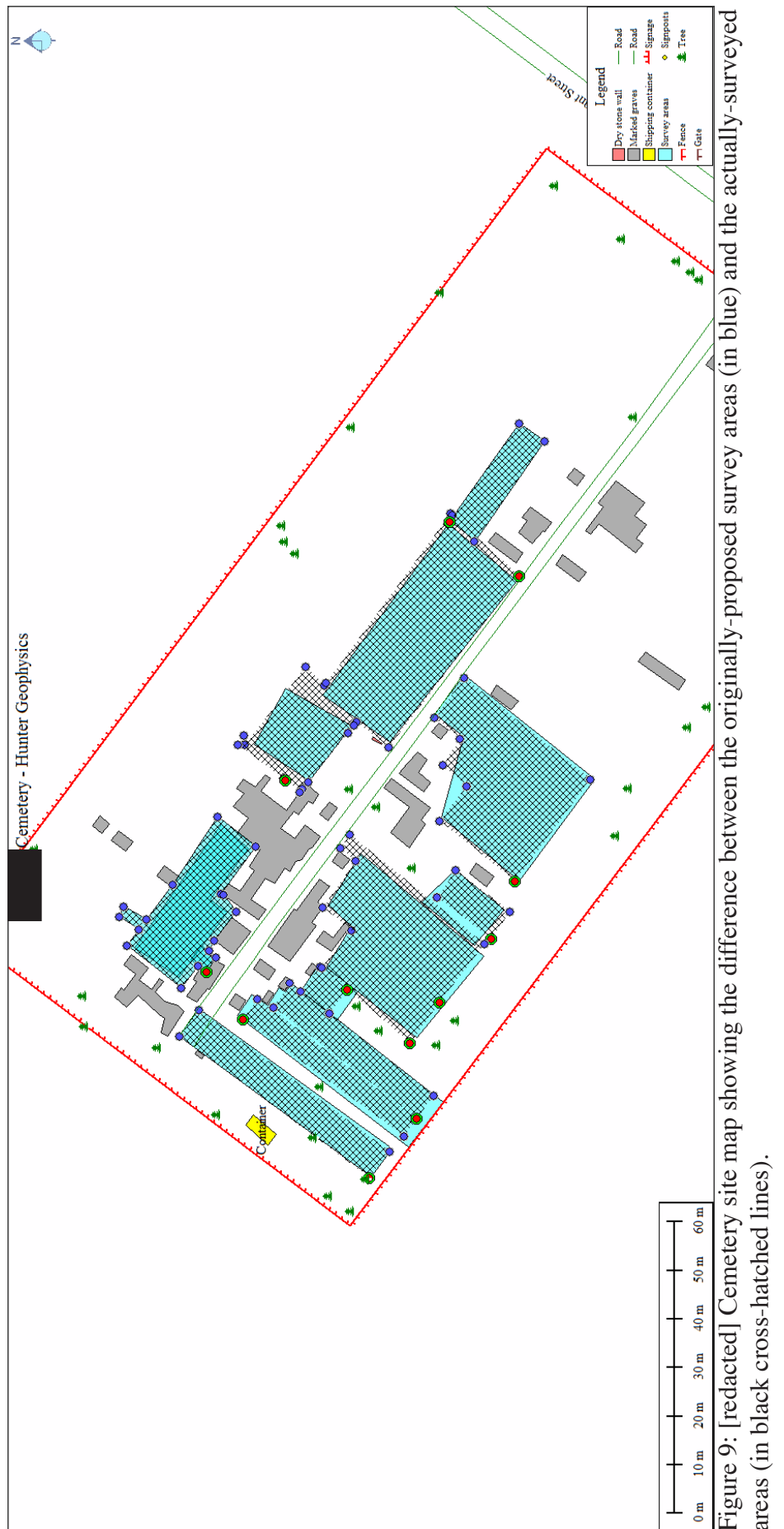


Figure 9: [redacted] Cemetery site map showing the difference between the originally-proposed survey areas (in blue) and the actually-surveyed areas (in black cross-hatched lines).

All survey traverses were staked-out using brick-layers string to ensure complete survey grid coverage. Traverses were spaced at 25cm intervals, with each GPR trace being recorded at 5cm intervals along each traverse. Each GPR trace was recorded with a time-window of 110.4 nanoseconds.

Data were collected automatically by a computer using an odometer wheel calibrated at the beginning of the survey. In this manner, GPR traces are recorded autonomously as the surveyor pushes the GPR system along the traverse. The data were stored in an internal data logger and downloaded to a field computer via the system's memory card.

A total linear distance of 16,512.45 metres was covered by the survey traverses.

A small area between monuments to the immediate west of the northwestern end of grid P1G1 (i.e. to the immediate northwest of the large tree in the middle of the cemetery) was also surveyed using ground-penetrating radar. However, as the area was too small to collect a 'grid' of geophysical data, the radargrams from this area were interpreted on-the-fly (during data collection); substantial hyperbolic responses in the radargrams were assumed to be indicative of unmarked graves. The location of these responses were then marked on the ground using spray paint and were later mapped using the RTK GNSS receiver and entered into the cemetery map. The location of these detected graves are shown in figure 12 on page 19.

Data processing

Please refer to figure 8 on page 10 for a map showing where each survey grid was located.

The data were processed in the Geophysical Archaeometry Laboratory's GPR-SLICE software. Data processing routines were applied to the raw data in order to remove noise and enhance clarity.

[redacted]

[Redacted]

[Redacted]

Reporting, mapping and archiving

The geophysical survey and report follow the recommendations outlined in the English Heritage Guidelines (David 1995) and IFA Paper No. 6 (Gaffney et al. 2002) as a minimum standard. Mapping was performed using a Topcon GR-3 real-time kinematic global navigation satellite system (RTK GNSS), providing a precision of less than one centimetre in the horizontal plane, and less than two centimetres in the vertical plane. This is of a higher precision than that required by the English Heritage Guidelines and Aboriginal Affairs Victoria requirements (both of which require a half-metre precision as a minimum).

Geophysical data, figures and text are archived in-house following the recommendations of the Archaeology Data Service (Schmidt 2001). All data, figures and text are also provided to the client and are submitted to Heritage Victoria for archival.

Results

Ground-penetrating Radar survey

The ground-penetrating radar survey revealed the location of unmarked graves within the survey areas. A minimum of 256 unmarked graves have been located, along with the possible foundations of a gazebo. Additionally, other areas of uncertain soil disturbance have been located; these areas are consistent with rabbit burrowing, ‘floating’ boulders within the soil matrix, and plant root systems. Please note that these interpretations are subject to a level of uncertainty as explained on page 2; it is possible that these features may, indeed, be unmarked graves.

Data collected immediately southwest of the dry stone wall (i.e. the data collected in grid P1G1) indicate the presence of buried foundations of the gazebo mentioned by Mr [redacted] (see section “Site history” on page 8 for details).

The following pages contain maps which show the location of all detected features. In the interest of minimizing printing costs, image plots of the geophysical data itself are available only on the accompanying USB memory stick in digital format (please refer to page 25 for details).



Figure 10: map showing the location of detected features within survey grids P1G1 and P1G2.

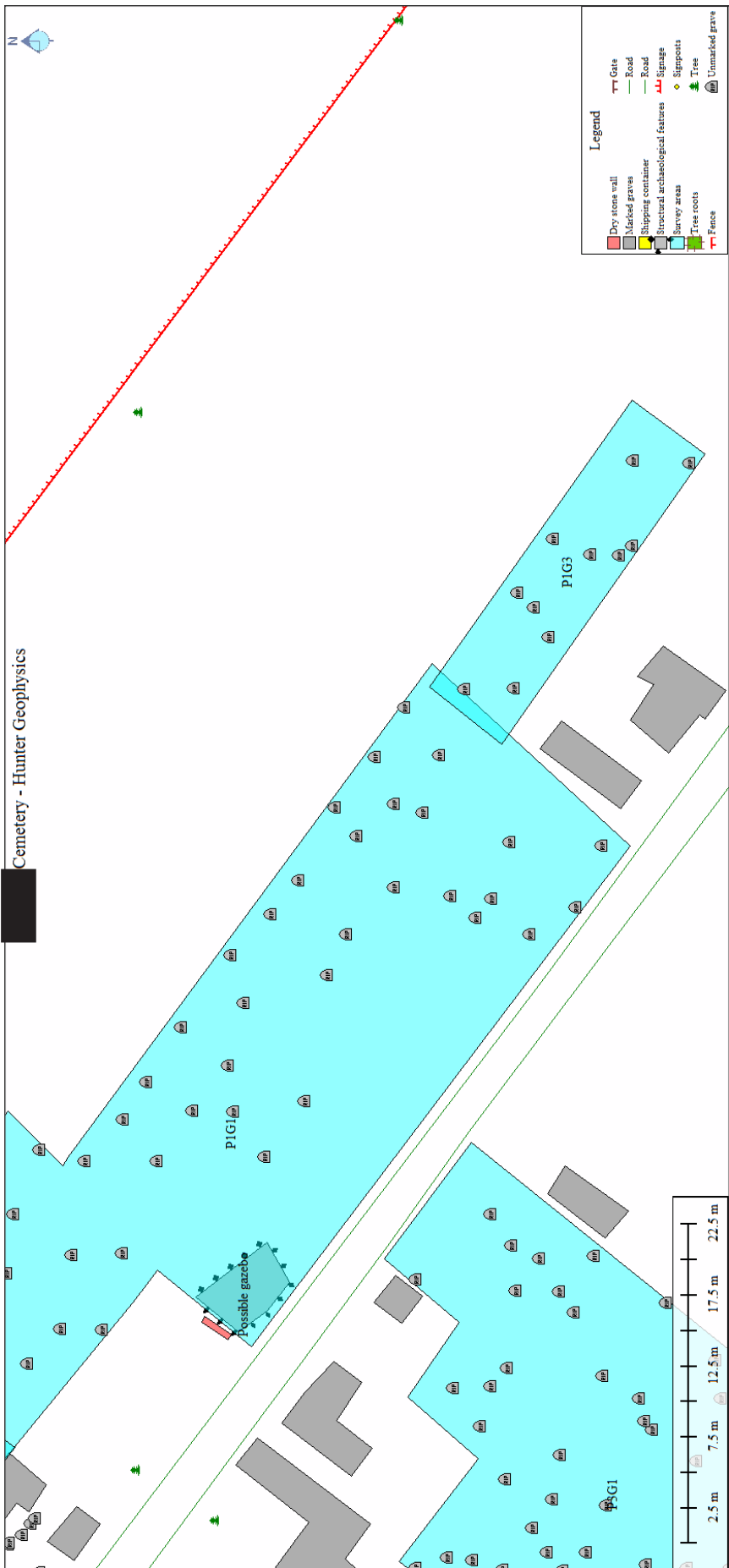


Figure 11: map showing the location of detected features within survey grids P1G1 and P1G3.



Figure 12: map showing the location of detected unmarked graves in the small area between headstones to the northwest of the large tree in the centre of the cemetery. Survey grids P1G1 and P1G2 are also shown (in blue).

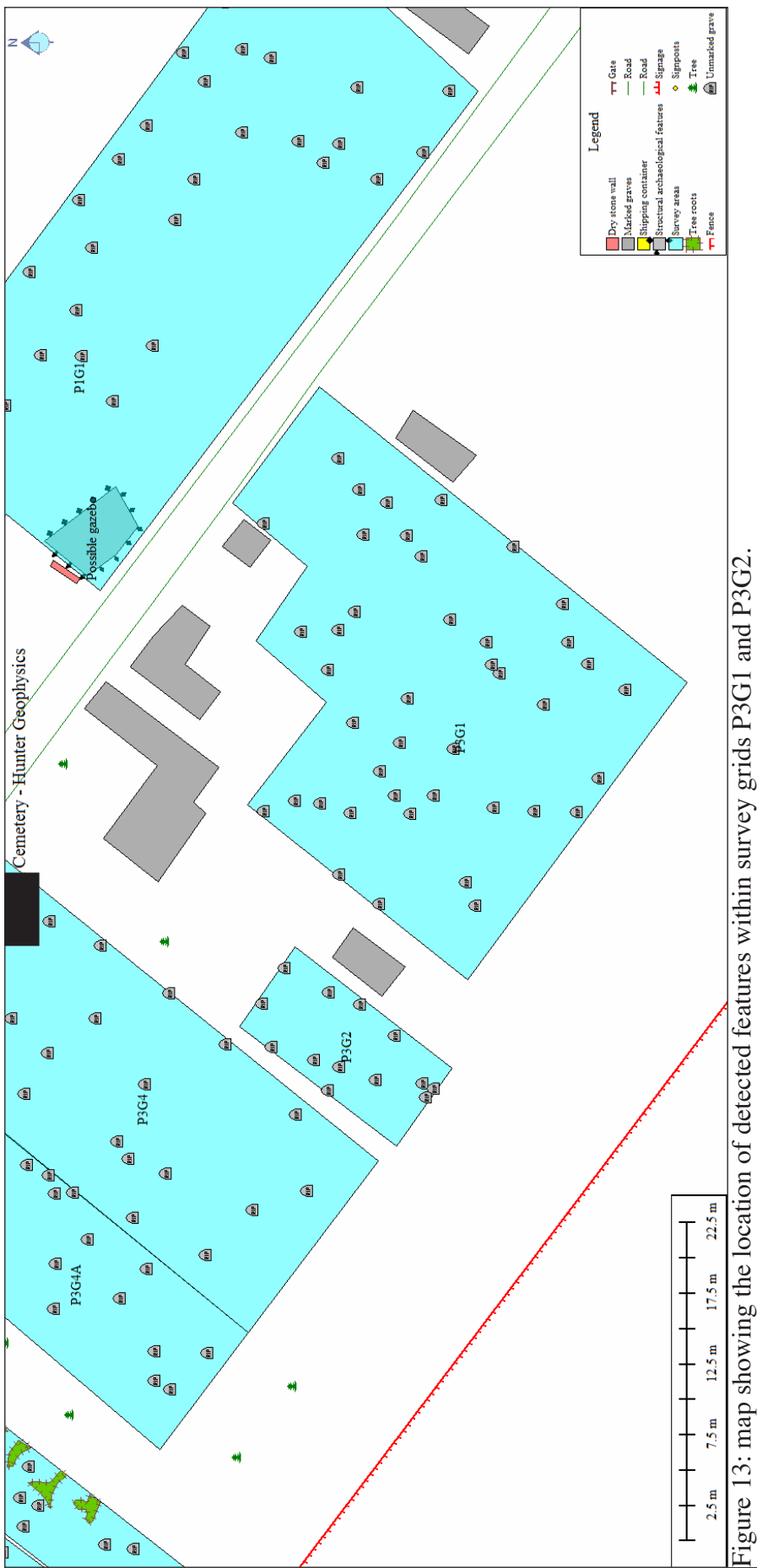
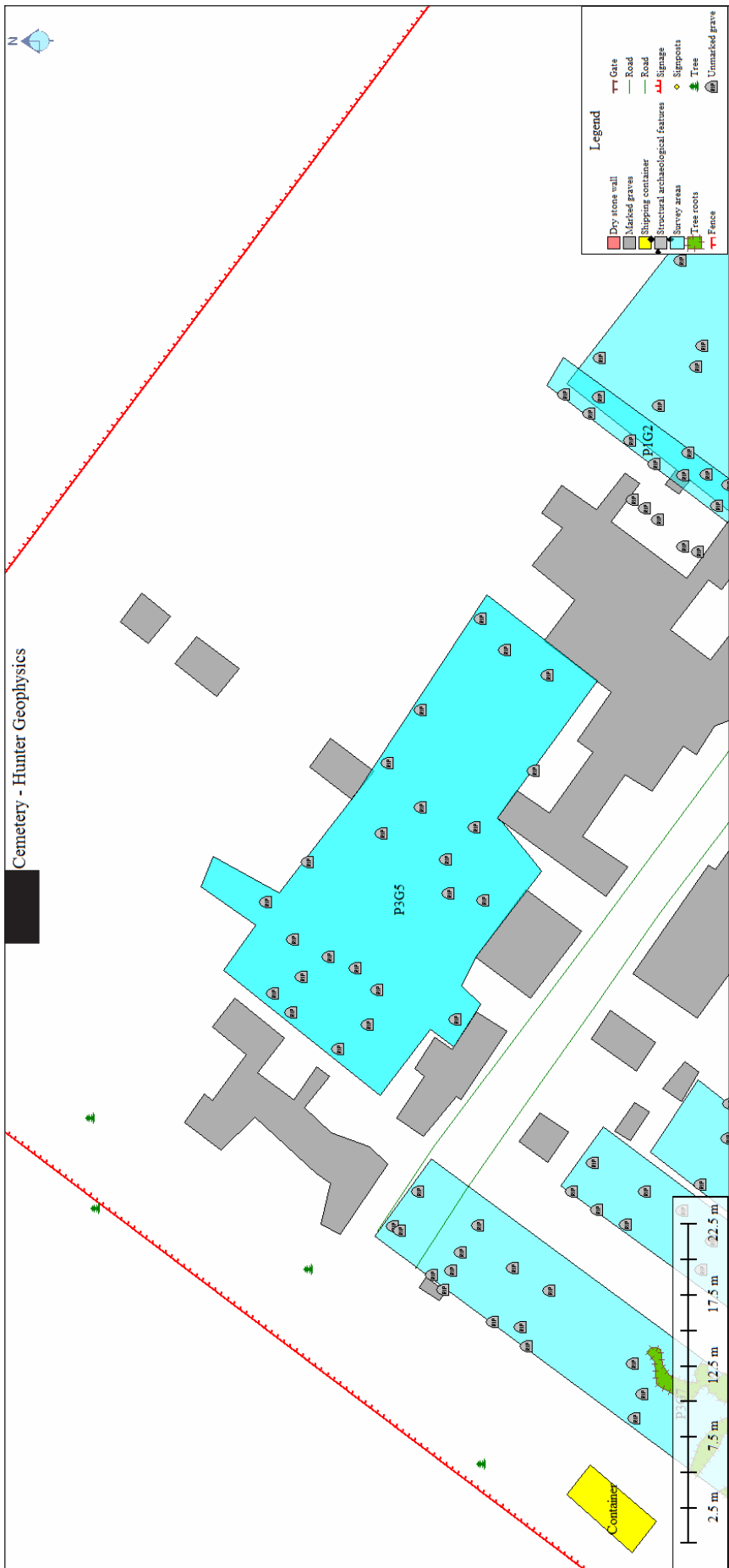


Figure 13: map showing the location of detected features within survey grids P3G1 and P3G2.



Figure 14: map showing the location of detected features within survey grids P3G3, P3G4, P3G4A, P3G6 and P3G8.



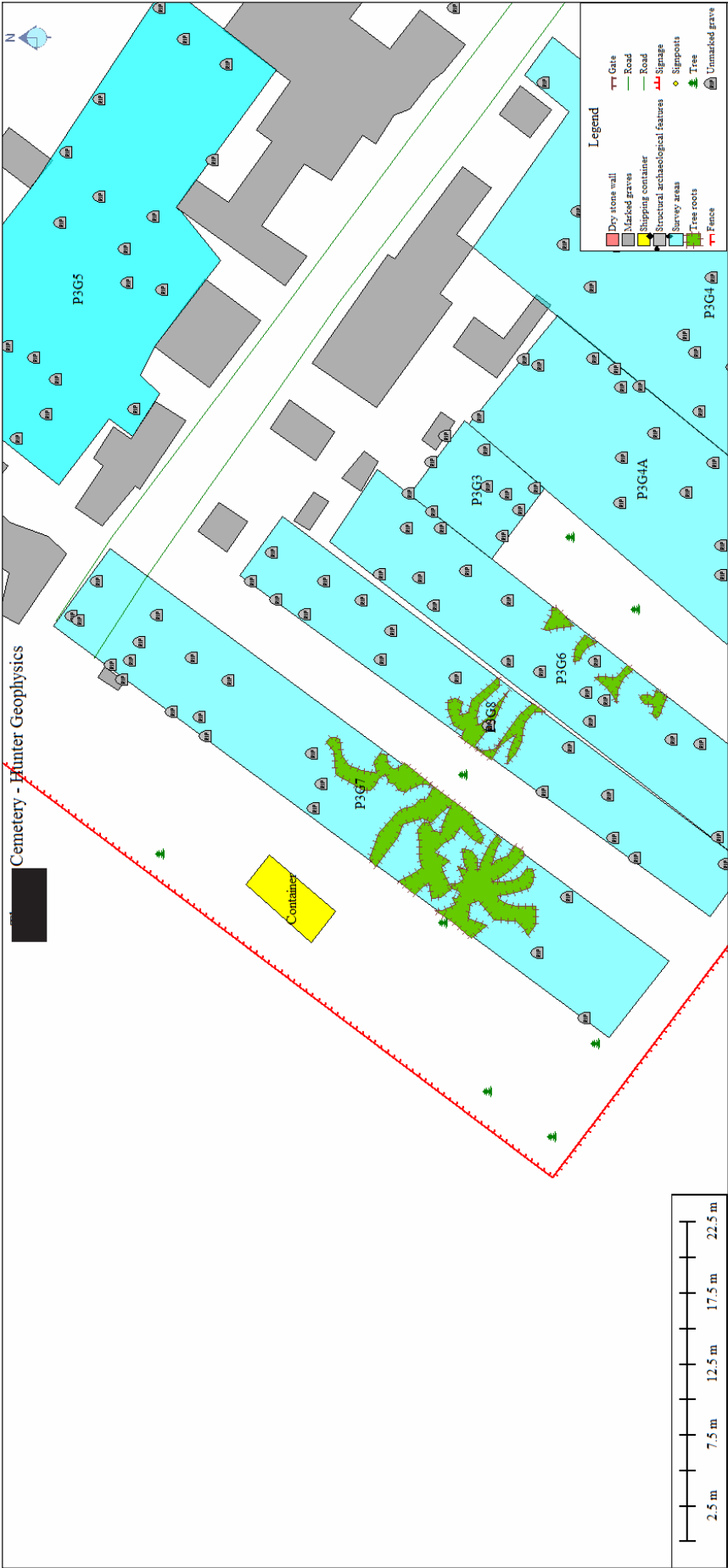


Figure 16: map showing the location of detected features within survey grid P3G7.

Acknowledgments

Fieldwork:	David Hunter Shannon Hunter
Report:	David Hunter
Advisors:	Dean Goodman PhD (Geophysical Archaeometry Laboratory) Alex Birtwistle BSc (Atlas Geophysical Limited) Prof Allen Gontz (University of Massachusetts Boston) Alexandre Novo PhD (Geophysical Archaeometry Laboratory) Jason Jeandron BA (Hons), MPhil (Archaeological Prospectors)

Conclusion

Satisfaction of objectives

The geophysical survey undertaken for this project has successfully located the unmarked graves present in the survey areas at the [redacted] Cemetery.

Summary of results

The survey has located at least 256 areas of disturbed soil stratigraphy most likely to be associated with unmarked grave shafts and funerary urn burials and other areas of soil disturbance which may be indicative of unmarked graves or other buried features. The survey has also revealed the possible foundations of a gazebo.

Geophysical research value

[redacted]

Dissemination

This report was submitted to the [redacted] Cemetery Trust in May 2014. Hunter Geophysics will also send copies of the report, along with all digital data, to Heritage Victoria as per legislative requirements.

Recommendations

Given the findings of this report, Hunter Geophysics recommends the marking out of detected unmarked graves on the ground surface as such will make the results of this survey more readily accessible. The client also expressed interest in the creation of a map showing the location and details of marked graves.

Hunter Geophysics are capable of meeting both of these requirements should the client so desire and a written quotation will be provided to the client over the coming weeks.

What's on the USB

A Universal Serial Bus v3 (USB) memory stick is included with this report. The following files may be found on the memory stick in digital form:

- All figures included in this report.

- The report itself in Adobe InDesign v8 format and also in Adobe Portable Document Format (PDF).

- Site map file (with a .gmp file extension) for use with Global Mapper v15.1 or later.

- All geophysical datasets in their own proprietary digital formats.

N.B.: A demonstration version of Global Mapper - which allows viewing of GIS data - is available from the Blue Marble Geographics website at <http://www.blumablegeo.com/products/global-mapper-download.php>.

References

BUREAU OF METEOROLOGY, 2014, '[redacted], Victoria - February 2014 Daily Weather Observations' (accessed via [redacted] on 20th April 2014).

BUREAU OF METEOROLOGY, 2014, '[redacted], Victoria - March 2014 Daily Weather Observations' (accessed via [redacted] on 20th April 2014).

DAVID, Andrew, 1995, 'Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines', No. 1. English Heritage.

GAFFNEY, Chris, GATER, John. and OVENDEN, Susan, 2002, 'The use of Geophysical Techniques in Archaeological Evaluations', IfA Paper No. 6. Institute for Archaeologists.

GEOLOGICAL SURVEY OF VICTORIA, '1:250,000 Geological Map Series: [redacted]' (accessed via [redacted] on 18th February 2014), 2nd edition, published by the Department of Natural Resources and Environment, May 1997. Copyright currently held by the Department of Environment and Primary Industries.

SCHMIDT, Armin, 2001, 'Geophysical Data in Archaeology: A Guide to Good Practice.' Archaeology Data Service, Oxford, Oxbow.

[redacted], D, of the [redacted] Cemetery Trust, in personal communication to the author, 1st March 2014.

Hunter Geophysics - PO Box 1445, Central Park, Victoria 3145
Ph. 03 9913 2259 or Mob.: 0488 501 261
david.hunter@huntergeophysics.com
www.huntergeophysics.com

Specialists in unmarked grave detection and archaeological prospection.

Copyright 2014 Hunter Geophysics